Non-Aqueous Phase Liquid (NAPL) Recovery Testing Results - Quanta Resources Superfund Site

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1.0 Introduction

The field work described below was performed in general accordance with the December 2006 Scope of Work (SOW) submitted to the United States Environmental Protection Agency (USEPA) by CH2M HILL. As stated in the SOW, the field work was designed to remove non-aqueous phase liquid (NAPL) from select monitoring wells with thickest NAPL accumulation [as observed during 2005-2006 Remedial Investigation (RI) activities]. The field work, including pumping NAPL from the monitoring wells, was performed on July 10 and 11, 2007 with follow up measurements conducted on July, 18, 2007 and August 13, 2007. The monitoring wells included in this activity were MW-102, MW-102A, MW-102B, MW-103, MW-105, MW-112A, MW-112B, MW-116A, MW-116B, MW-117A, and MW-118B. MW-107 was inaccessible during the July 2007 pumping event. The objectives of this work were as follows:

1.) To recover NAPL from the Site;

2.) To collect additional data on the recoverability and mobility of NAPL at the select monitoring wells; and

3.) To evaluate the behavior of measurable NAPL in the monitoring wells over time.

It should be noted that recovery efforts performed at the Site were not intended to serve as pilot test activities, and as such a definitive evaluation of these measures ability to effectively recover NAPL at the Site for an extended period of time was not evaluated as part of this technical memorandum.

The event described in this memorandum constitutes the summer event with a previous event conducted in the winter of 2006 to evaluate NAPL recoverability and mobility under varying seasonal and water table conditions. A comparison of observations/measurements between these two events is also discussed in this document and presented in Table 1. A memorandum summarizing the observations and measurements for the December 2006 NAPL recovery event was submitted to EPA on March 8, 2007. Based on the observations and recommendations reported in the memorandum for the December 2006 event, a peristaltic pump was used during the July 2007 event instead of a vacuum truck in order to

minimize generation of excess amounts of groundwater due to the inability to observe the effluent fluid being pumped from the wells and difficulty in gauging the volume of NAPL being recovered.

For the purpose of the July 2007 event the list of wells evaluated was expanded to include all wells on the Quanta property that had measurable thicknesses of NAPL greater than three inches. Previously, monitoring wells included in the December 2006 event included those that had a measurable NAPL thickness greater than 0.5 feet. The inclusion of wells with lesser measurable thicknesses during the most recent event was intended to expand the understanding of recoverability of NAPL across a wider set of wells at the Site. .

2.0 Field Procedures (Quanta Property)

On July 10, 2007 the NAPL recovery testing commenced. Each day, task specific hazards, as well as site-specific hazards, were reviewed as part of the daily tailgate safety meeting prior to commencement of work. Work involving NAPL was performed in modified level D personal protective equipment including poly-coated tyvek, nitrile gloves, as well as steel-toed boots, and safety glasses.

Prior to deployment of the peristaltic pump intake the NAPL thickness was measured at the following wells:

MW-102	MW-103	MW-112A	MW-116A	MW-117A
MW-102A	MW-105	MW-112B	MW-116B	MW-118B
MW-102B				

Based on observations and confirmed by the analysis of NAPL samples from a select number of these wells these NAPLs are slightly denser than water, and as such resides at the bottom of each of the wells where they are found. A summary of the results of the physical analyses performed on NAPL samples collected from monitoring wells at the Site is included in Table 2.The NAPL thickness at each location was measured by lowering a small weight attached to string through the NAPL interval, removing the NAPL-stained string, and measuring the stained length of the string. In the case of the more viscous NAPL observed in MW-105 a rigid 0.75-inch diameter polyvinyl chloride (PVC) pipe was used in place of the weighted string. The use of an oil/water interface probe had been attempted during past field events at the site with limited success, either due to emulsification of NAPL resulting in it being suspended in the water column, the general lack of response by the probe to the NAPL(s) in the monitoring wells at the site, and/or the inability of the probe to penetrate the more viscous NAPL at MW-105.

NAPL extraction activities began with lowering a 0.5-inch outside diameter polyethylene tubing to a depth that corresponded approximately with the bottom of each well. At the ground surface, the tubing was connected to the peristaltic pump and the extraction was initiated by starting the pump and maximizing the flow rate. The purged fluid was discharged into 5-gallon buckets. If the viscosity of the NAPL caused pumping difficulties, the field staff surged the tubing by rapidly and repeatedly raising and lowering it to aid the pumping process. Pumping was performed at each location for a period of two hours. At monitoring well MW-112B a weighted Teflon bailer was also used due to the elevated

viscosity of the NAPL which clogged the polyethylene tubing. The bailer was lowered to the bottom of the well, raised from the well, and the contents of the bailer were emptied into 5-gallon buckets. The NAPL was transferred from the 5-gallon buckets into DOT-approved 55-gallon drums and stored on-Site for subsequent disposal.

In general the monitoring wells were dewatered completely during the 2 hour purge event. For those wells where all the contents of the well were not removed the consistency of the remaining NAPL/water mixture (viscous and mixed with water) did not allow for an immediate NAPL thickness measurement. Approximately 2 hours following the completion of the NAPL removal activities the NAPL thickness at each location was gauged to evaluate recovery. Additional measurements were also taken at each location at one week, and again at one month following the NAPL removal. A summary of these data are provided in the attached Table 1.

In order to determine the volume of NAPL pumped from each well relative to the amount of groundwater removed, the contents of the 5-gallon buckets were measured following the completion of the NAPL extraction activities at each monitoring well by lowering a measuring device to the bottom of the bucket to gauge how much of the volume of recovered liquid was comprised of NAPL versus groundwater (dipstick method).

3.0 Summary of NAPL Recovery Efforts

The following paragraphs provide a summary of the observations and recovery efforts and results for each well.

- MW-102: The pre-purge NAPL thickness was 1.5 feet. During the first five minutes of purging NAPL was predominantly being pumped out of the well at a rate of approximately 0.5 liters per minute. After approximately 3.5 gallons the well ceased to yield any water or NAPL. It was speculated that the fluid flow in the tubing was impaired due to the viscosity of the remaining NAPL present in the well. Once new tubing was installed the well began to yield a groundwater/NAPL mix. The field staff surged the tubing allowing the viscous NAPL to travel through the tubing in short spurts (approximately 2 seconds of NAPL followed by 30 seconds of grey water). The total purge volume from MW-102 was approximately 6 gallons of NAPL and 6 gallons of groundwater. The final NAPL thickness when purging was complete was 0.1 feet, after two hours and one week the measured NAPL thickness remained at 0.1 feet, and after one month only trace amounts of NAPL was measured (<0.1 feet).

- MW-102A: The pre-purge NAPL thickness was 7.0 feet. During approximately the first 30 minutes of pumping a water/NAPL mix was purged from the well. When the tubing was surged, NAPL was pumped for approximately 30 seconds followed by a groundwater/NAPL mix. The final NAPL thickness was 0.15 feet, and the two hour thickness measurement was 1.0 feet (a 14% rebound). The total purge volume from MW-102A was approximately 10 gallons of NAPL and less than a gallon of groundwater. After a period of one week the NAPL in MW-102A had almost completely rebounded to a measured thickness of 6.9 feet. The one-month measurement was 7.3 feet indicating a NAPL thickness slightly greater than the pre-purge thickness.

- MW-102B: The pre-purge NAPL thickness was 0.5 feet of discontinuous (e.g., slightly suspended or emulsified) NAPL. Approximately 4 gallons of NAPL and 11 gallons of groundwater were purged from MW-102B. The final NAPL thickness when purging was complete was 0.1 feet of NAPL, and after two hours it remained at 0.1 feet. After one week and one month no measurable thickness of NAPL was observed.

- MW-103: The pre-purge NAPL thickness was 1.8 feet. The viscosity of the NAPL at this location clogged the tubing. Surging of this well was performed throughout the duration of the NAPL purging. The total purged volume at MW-103 was approximately 3 gallons of NAPL and 3 gallons of groundwater. Upon completion of the NAPL extraction the thickness was measured to be 0.1 feet, after two hours the NAPL thickness remained unchanged at 0.1 feet. The one week measurement was also 0.1 feet indicating there was no rebound of NAPL. The one-month measurement was a trace of NAPL (less than 0.1 feet) at the bottom of the measuring device.

- MW-105: The pre-purge NAPL thickness was 11.2 feet. Due to the elevated viscosity of the NAPL found in this monitoring well, its significant thickness, and the difficulties encountered when purging the NAPL from MW-118B (an adjacent monitoring well containing NAPL with a similar viscosity), removal of NAPL from this well using a peristaltic pump was not attempted. A NAPL thickness measurement was collected by pushing a 0.75 inch diameter PVC pipe through the NAPL interval to the bottom of the well, and measuring the residual tar on the pipe. It should be noted that the PVC pipe had to be very forcibly lowered by two field staff in order to penetrate the NAPL at this location due to its elevated viscosity. The physical properties of the NAPL at MW-105 also render a weighted bailer ineffective in removing NAPL. An alternate methodology for removing NAPL at this location is discussed in the Recommendations section below.

- MW-112A: A NAPL thickness of 0.1 feet was measured. No attempt to purge NAPL was undertaken here due to the small volume of NAPL present in the well.

- MW-112B: The pre-purge NAPL thickness was 2.5 feet. Initial pumping of the well was performed with a peristaltic pump for a short duration until highly viscous NAPL clogged the tubing. A bailer was then used to purge the well. With the bailer it was possible to purge the viscous NAPL at the bottom of the well. After several deployments of the bailer in which 4 gallons of NAPL were removed, the peristaltic pump was reapplied to remove an additional gallon of NAPL. The total amount purged was approximately 5 gallons of NAPL and 5 gallons of groundwater. The final NAPL thickness measurement was 0.35 feet. After two hours the measured thickness was 0.3 feet, after one week it was 0.75 feet, and after one month it was 1.9 feet.

- MW-116A: A NAPL thickness of 0.1 feet was measured. No attempt to purge NAPL was undertaken here due to the small volume of NAPL present in the well.

- MW-116B: The pre-purge NAPL thickness was 6.0 feet. The total purged volume at MW-116B was comprised of approximately 9 gallons of NAPL and 2 gallons of groundwater. The final NAPL thickness measurement was 0.25 feet. After two hours the measured thickness was 1.2 feet (some suspended, emulsified NAPL was believed to be present in the water column above at this time evidenced by intermittent staining on the measuring device above the continuous, thick NAPL interval staining). After one

week the measured thickness measurement was 2.0 feet and after one month it was 3.7 feet.

- MW-117A: A NAPL thickness of 0.25 feet was measured. No attempt to purge the NAPL was undertaken here due to the small volume of NAPL present in the well.
- MW-118B: The pre-purge NAPL thickness was 0.75 feet. The viscosity of the NAPL at this location caused the tubing to become clogged. Surging of this well was performed with limited success. In order to get the tubing into the NAPL interval at the bottom of the well it was secured to a 0.75-foot piece of PVC pipe. The PVC pipe was effective in delivering the tubing into the NAPL interval and dislodging some of the viscous NAPL; however, the effectiveness of the peristaltic pump was limited as it was unable to pump all of the viscous NAPL. The total purged amount at MW-118B was approximately 2 gallons of NAPL and 8 gallons of groundwater. The final NAPL thickness measurement was 0.33 feet. After two hours the measured NAPL thickness was 0.25 feet. After one week and one month the measured thickness was 0.5 feet.

4.0 Evaluation of NAPL Recovery Efforts

In general NAPL thickness at the wells measured during the July 2007 event were similar to those measured during the December 2006 event and ranged between 0.1 feet at MW-116A and 11.2 feet at MW-105. Groundwater elevations at each of the wells measured across both events were all within 0.1 feet of the elevations measured in December 2006. With such similarities in groundwater elevations the effects of water table fluctuations on NAPL recoverability could not be evaluated using these data sets. A summary of the NAPL thicknesses measured during both events is included as part of Table 1. During this event a total of approximately 39 gallons of NAPL and 35 gallons of groundwater (approximately a 1 to 1 ratio) were removed from a total of 7 monitoring wells.

With the exception of MW-102A, and MW-116B, each well that was purged during the July 2007 event yielded a volume of NAPL that was greater than the volume of NAPL estimated to be residing within the well and the filter pack prior to the initiation of removal activities, indicating that in most cases, pumping was effective at moving NAPL from the adjacent formation into the well. A summary of these estimates for each well and the methodology used to calculate them is included in Table 1.

At MW-102A and MW-116B the volume of NAPL estimated to be within each well and adjacent sand pack was approximately 11.8 and 10.1 gallons, respectively. Based on the estimated pumping rate during extraction these large volumes were unable to be recovered within the 2 hour time frame that was allotted for each well. Hence, the comparison of the volume of NAPL purged to that which was within the well and adjacent sand pack prior to pumping is not an indicator of the effectiveness of NAPL extraction at these locations. In fact, upon review of these numbers for the December 2006 event (Table 1) it appears that over 2 times the volume of NAPL within the well and sand pack was removed from monitoring well MW-102A during that event, suggesting, like the other wells, that NAPL recovery extraction efforts were effective in removing NAPL from the formation. MW-116B, on the other hand, showed no better connectedness with NAPL in the adjacent formation during the December 2006 event, as only the volume of NAPL within the well and sand pack was recovered after six attempts with the vacuum truck.

The recovery of NAPL thickness in each well over time also provides information on the recoverability and behavior of NAPL at various locations across the Site and over time. In general, measured NAPL thickness one month after pumping remained at less than 50% of the amount measured prior to the December 2006 pumping event[1]. One month following the July 2007 pumping event, nearly all wells that had been pumped were each found to contain a NAPL thicknesses that were within approximately 75 percent of their initial, pre-purge NAPL thickness. The one exception to this was at MW-102A where NAPL had almost fully recovered after one week and more than fully recovered after a period of one month. During the December 2006 event rapid NAPL thickness recovery was also observed at MW-103 and MW-105 (Table 1).

5.0 Conclusions

Despite the elevated viscosities of NAPL observed across much of the Site (Table 2), particularly in the vicinity of MW-105, extraction and recovery at most locations has been shown to be feasible during one or more of the NAPL recovery events performed to date. For the purposes of this memo, feasibility is defined as recovery of 75% of original NAPL thickness in the well.

It should be noted that the wells that were used during the recovery events were not designed for the purpose of NAPL extraction from the subsurface. Specifically, well diameters (between 2 and 4-inches), screen slot-sizes (between 10 and 20 slot), well materials, borehole diameters and sand pack selection in the existing wells have not been optimized for NAPL recovery. These are key factors known to enhance a wells ability to recover NAPL. In addition, using coal tar delineation data that has been collected subsequent to the installation of these wells to fine tune the vertical and lateral location of screen intervals for extraction wells that may be a part of a future selected remedy for the Site would also improve the efficiency of intended NAPL recovery efforts.

As previously stated the NAPL recovery testing results were not intended to provide the information necessary to design a long-term remedial system for NAPL removal. Instead, these tests were aimed at removing NAPL in the interim and determining the feasibility of using wells as a mean to recovery NAPL at the Site as part of the remedy for OU1. The data collected during these tests indicate that NAPL recovery using wells is feasible. However, if NAPL recovery is selected as remedial alternative, existing delineation data (TarGOST® and soil boring data) should be used in conjunction with additional NAPL recovery pilot testing to determine the design layout and parameters required for the implementation of an effective NAPL recovery system.

[1] NAPL thickness recovery data pertains solely to NAPL thicknesses as measured within monitoring wells and is not intended to be used whatsoever to make assumptions about NAPL thicknesses within the subsurface

TABLE 1
Summary of NAPL Recovery Event Results
December-January 2006 July 2007
Quanta Resources Superfund Site, OU1
Edgewater, New Jersey

Monitoring Well	MW-102		MW-102A		MW-102B	MW-103		MW-104R	MW-105		MW-107*	MW-112B		MW-116A	MW-116B		MW-117A	MW-118B
Date	Dec-06	Jul-07	Dec-06	Jul-07	Jul-07	Dec-06	Jul-07	Dec-06	Dec-06	Jul-07	Dec-06	Dec-06	Jul-07	Jul-07	Dec-06	Jul-07	Jul-07	Jul-07
Baseline NAPL Thickness (ft.)	3.10	1.50	6.45	7	0.50	1.40	1.80	0.70	8.50	11.20	3.45	4.20	2.50	0.10	6.20	6.00	0.25	0.75
Estimated Vol. of NAPL in Well & Sand Pack (gal)	2.8	1.3	10.8	11.8	0.8	1.3	1.6	0.6	7.6	10.0	3.1	7.1	4.2	0.2	10.4	10.1	0.4	1.3
Number of Purge Events	2	1	3	1	1	5	1	3	5	0	2	3	1	0	6	1	0	1
Liquid Volume of IDW Purged (gal)	30	12	30	10	15	350	6	< 15	100	0	< 5	90	10	0	15	11	0	10
Approximation of NAPL Purged (gal)	3	6	24	10	4	20	3	0	22	0	< 5	25	5	0	10	9	0	2
Approx. No. of NAPL Volumes Removed	1.1	4.5	2.2	0.8	4.2	15.9	1.9	0	2.9	0	1.0	3.5	1.2	0	1.0	0.9	0	1.6
NAPL Recovered per Purge Event (gal)	1.5	6.0	8.0	10.0	3.5	4.0	3.0	0	4.4	0	<5	8.3	5.0	0	1.7	9.0	0	2.0
NAPL Recovery																		
Two-Hour Post-purge NAPL Thickness (ft.)	0.60	0.10	1.30	1.00	0.00	1.40	0.1	0.16	4.15	NM	0.00	0.25	0.3	NM	0.75	1.00	NM	0.25
One-week Post-purge NAPL Thickness (ft.)	0.80	0.10	5.30	6.90	0.00	1.70	0.1	0.20	7.00	NM	0.00	1.15	0.75	0.10	5.00^	2.00	0.75	0.50
One-month Post-purge NAPL Thickness (ft.)	0.9^	0.00	6.16	7.3	0.00	0.90	0.1	0.16	8.95	NM	NM	1.85^	1.9	NM	2.67	3.7	NM	0.50
NAPL Recovery (percent recovery relative to initial thickness)																		
2 Hours	19%	7%	20%	14%	0%	100%	6%	23%	49%	NM	0%	6%	12%	NM	12%	17%	NM	33%
1 Week	26%	7%	82%	99%	0%	121%	6%	29%	82%	NM	0%	27%	30%	NM	81%	33%	NM	67%
1 Month	29%	0%	96%	104%	0%	64%	6%	23%	105%	NM	NM	44%	76%	NM	43%	62%	NM	67%
	2-10		2-10		2-10													

Notes:

* MW-107 located on the former Lever Brothers property

^ Estimated measurement due to some suspension of the NAPL

NM - Not measured

Estimated Vol. of NAPL in Well & Sandpack = (Ft. of NAPL)x(gallons/ft of well)+[(Ft. of NAPL)x(gallons/ft of sand pack)x(porosity of sand pack)]

Volume in Well (gal) — Volume in Sand Pack (gal)

Porosity of sand pack assumed to be 30%

Bore hole and well diameters for MW-102, MW-103, MW-104R, MW-105, and MW-107 are assumed to be 8 and 2 inches, respectively (2.61 gal/ft and 0.163 gal/ft.)

Bore hole and well diameters for MW-102A, MW-112B, and MW-116B are assumed to be 10 and 4 inches, respectively (4.08 gal/ft and 0.653 gal/ft.)

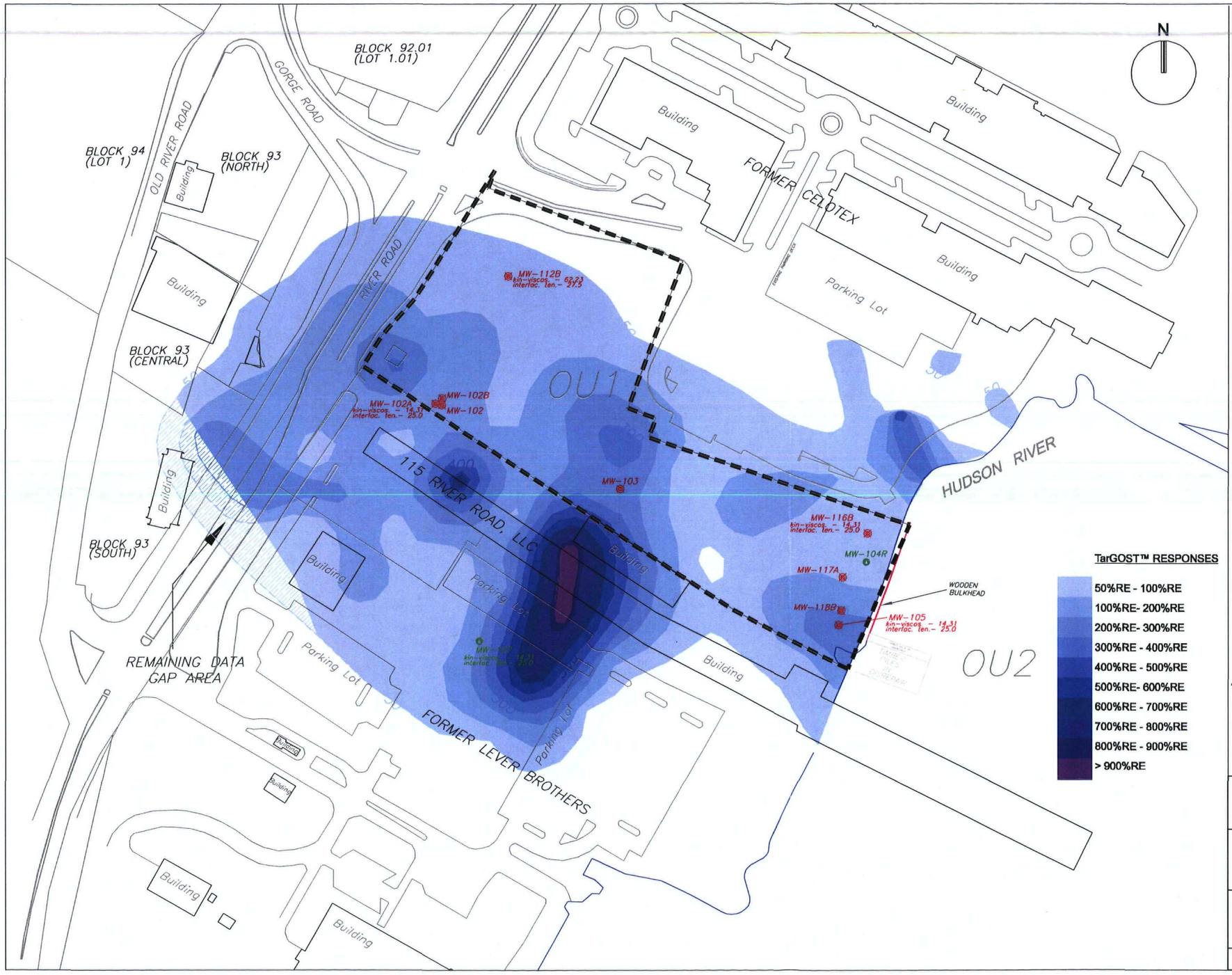
TABLE 2
Summary of NAPL Fingerprinting and Physical Parameters
Quanta Resources Site, OU1
Edgewater, New Jersey

Parameter	Method	Units	MW-102A	MW-105	MW-112B	MW-116B	MW-107
Type of Material**			Coal Tar	Coal Tar	Coal Tar	Coal Tar	Coal Tar
Kinematic Viscosity @ 122 °F	ASTM-D445	cSt	14.31	181.6	61.23	27.44	3.49
Viscosity SFS @ 122 °F	ASTM-D2161	Second	N/A	86.4	31.1	N/A	N/A
Interfacial Tension	ASTM-D971	Dynes/cm^2	25.0	30.2	27.5	18.0	8.2
API Gravity @ 60 °F	ASTM-D4052	°API	-2.32	NM	-4.81	-6.2	3.15
Density @ 60 °F	ASTM-D4052	kg/m^3	N/A	NM	N/A	N/A	1049.8
Specific Gravity @ 60 °F	ASTM-D4052	none	1.0951	NM	1.1168	1.1293	1.0505

Notes:
*Sampling conducted in 2003 was performed by Parsons. The type of material was determined, but the physical parameters of the samples were not analyzed.
**Type of Material is based on chemical analyses involving GC/FID fingerprinting (EPA Methods 8100 modifed) and EPA Method 8260 and 8270 (for VOCs, SVOCs and petroleum biomarkers). An evaluation of diagnostic ratios and the comparison of these results to the in-house library at META Environmental, Inc. of Watertown, MA was also used to determine material type.

Coal Tar: coal carbonization tars, coke oven tars and creosotes

ASTM - ASTM International
cSt - centistoke
SFS - Saybolt Furol Second
cm^2 - square centimeters
NM - American Petroleum Institute (API) Gravity reading was not measured because sample was thick with what appeared to be a sediment-like material.
N/A - Not applicable



LEGEND

MW-103 — MONITORING WELL LOCATION WHERE NAPL MEASUREMENTS AND/OR RECOVERY TESTING WAS PERFORMED DURING JULY 2007

MW-107 — MONITORING WELL LOCATION WHERE NAPL MEASUREMENTS AND RECOVERY TESTING WAS PERFORMED DURING DECEMBER 2006 (NOT INCLUDED IN JULY 2007 EVENT)

CURRENT PROPERTY BOUNDARY OF THE FORMER QUANTA RESOURCES PROPERTY

HUDSON RIVER SHORELINE

NOTES:
1. Depiction of other properties on this figure is for comparative purposes and does not neccessarily suggest that site-related constituents have migrated there.
2. Kin. viscosity: kinematic viscosity (centistoke) . Measured at 122 degrees F using method ASTM-D445.
3. Interfac. ten.: Interfacial tension (dynes/cm2). Measured using method ASTM-D971.

Basemap Sources:

a.) Boundary and topographic survey of Block 95, Lot 1 and Block 93, Lots 1,2, and 3 performed by Vargo Associates in September 2005 and updated as recently as June 2007.
b.) Borough of Edgewater Tax Map - November, 1959
c.) Coal Tar Engineering Design Report (Environ, July 2005)
d.) Site Investigation Report, Part 4 (Langan, May 2004) for the former Lever Bros. Property.

GRAPHIC SCALE

160 0 80 160 320

(IN FEET)

CH2MHILL

NAPL RECOVERY TESTING MONITORING WELL LOCATIONS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

October 4, 2007 | FIGURE 1